



FINAL REPORT

FABRICATION OF ESSEX EVA RATCHET WRENCHES

Contract NAS8-34925

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## FOREWORD

This final report is submitted to NASA/MSFC to complete the requirements of NASA Contract NAS8-34925 for the fabrication and delivery of flight-qualified EVA ratchet wrenches. The report describes the end item deliverables as well as the tasks performed in support of the deliverables.



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## 1.0 INTRODUCTION

The extravehicular activity (EVA) ratchet wrench is the culmination of over two year's of NASA development work, with the Essex Corporation performing much of the initial development as well as the final design. Shortly after Space Telescope (ST) maintenance simulations began, the need for a specialized maintenance tool arose. With inputs of tool requirements and design recommendations from Bruce McCandless and others, Essex fabricated several development model wrenches which were tested in conjunction with ST neutral buoyancy (NB) simulations. The wrench design was gradually modified and refined to its present state. The wrenches will be used on STS-5 and possibly on future flights including the Solar Max Repair Mission and the Space Telescope deployment and servicing mission.

This final report describes Essex' fulfillment of the requirements of NASA contract NAS8-34925. The contract was granted for the fabrication and delivery of two Essex-designed, flight qualified EVA ratchet wrenches per drawing number ESEX-82-27-10 for use on STS-5 and one flight-like prototype for test and evaluation at Johnson Space Center (JSC). Contract requirements in support of the wrenches included a quality assurance plan to be administered to the units as well as acceptance tests, cleaning and packaging to NASA standards, complete documentation, and appropriate DD 250 forms.

The contract called for one prototype unit to be delivered to JSC via Marshall Space Flight Center (MSFC) on May 15, 1982, which was accomplished with the delivery of EVA ratchet wrench serial number 1004. However, due to minor design changes agreed to by NASA, it was decided that a second prototype would be delivered identical in design and fabrication to the two flight wrenches for more accurate translation of test results to expected flight unit performance. Therefore, EVA ratchet S/N 1004 was returned to Essex. When the two flight wrenches (S/N's 1005 and 1006) were delivered to NASA/MSFC on June 25, 1982, a third wrench (S/N 1007) was sent to replace the S/N 1004 prototype wrench. The S/N 1007 prototype wrench bore the engraving "NOT FOR FLIGHT" to distinguish it from the other two wrenches.



## 2.0 TASK DESCRIPTION

### 2.1 FABRICATION OF THREE WRENCHES

Three EVA ratchet wrenches were fabricated, finished and assembled per released Essex Corporation drawing ESEX-82-27-10 (sheets 1 through 8). All individual parts not purchased from manufacturers were fabricated in the Essex Machine Shop. Heat treating, engraving, bead blasting, anodizing, passivating and electropolishing were performed by local shops on a subcontract basis. The units were assembled by shop personnel under supervision of MSFC Reliability and Quality Assurance (R&QA) personnel and the COR.

### 2.2 ESTABLISHMENT OF QUALITY ASSURANCE PLAN

A quality assurance plan was established by Essex under the supervision and approval of the MSFC Reliability and Quality Assurance Office. This plan was implemented in the fabrication and delivery of three EVA ratchet wrenches for the control of materials, to verify that drawing requirements were met, and to provide permanent records to this effect.

Quality assurance efforts on the part of Essex began with the development of a quality assurance manual. A locked material control area was constructed, and a material inventory control system was implemented, including numbered tags for all raw materials and purchased parts as well as stowage of all material certifications and invoices. As individual wrench parts were fabricated and finished, they were inspected by the shop supervisor using the Essex-developed inspection report. All approved parts were cleaned and placed in a locker for later retrieval, and all nonconforming parts were bagged with a card labeled "Rejected" on which a description of the nonconformance was written.

### 2.3 ACCEPTANCE TESTING

Following assembly, the three wrenches were tested in the presence of NASA R&QA personnel, the NASA COR and Essex personnel according to the Essex EVA Ratchet Wrench Acceptance Test HD-82-01. The acceptance test included the use of all functional parts and a proof load test of 65 lbs/ft which is approximately 150% of the maximum load expected to be encountered by the wrench. Steps in the acceptance test were repeated at least four times.

### 2.4 CLEANING PROCEDURES

Following assembly, the three wrenches were cleaned in MSFC Building 4705 clean room in accordance with SN-C-0005, VC Level 1. The units were then double bag sealed with appropriate identification sealed between the inner and outer bags.



## 2.5 PACKING AND SHIPPING

The three bagged wrenches were placed in plywood shipping containers with custom molded foam packing. The containers were then sealed and labeled for shipment to JSC.

Also packed for shipment to JSC was a data pack including six sets of engineering drawings, material certifications, inspection reports, test reports, blank test sheets (for JSC testing), and a Deviation Approval Request sheet.

As the wrenches and data pack were shipped to JSC, DD 250 forms were distributed at NASA/MSFC.

## 2.6 DESIGN MODIFICATIONS AND DRAWING DEVIATIONS

Following delivery of prototype ratchet S/N 1004 to JSC, several design modifications were decided upon by Essex and agreed to by NASA. The most prominent of these changes included:

- o Replacement of the pawl detent ball with a plunger--to tension direction pawl with less chance of binding
- o Addition of bronze bushing to direction pawl shaft--to provide a more free running surface in wrench head
- o Addition of shoulder on push button--to prevent excessive play in push button
- o Elimination of sleeve to retain quick release ball--to allow easier disassembly and reduce chance of accidental dislodging.

All design changes implemented are reflected on released engineering drawings.

A few deviations in the delivered wrenches were not reflected on the released set of drawings. These deviations are described below.

- o Two helicoil inserts and two set screws on each wrench were too long as delivered by the manufacturer. Therefore they were shortened enough to allow positioning flush with wrench outer surface.
- o One dimension on the palm wheel called out as  $.700" \pm .004"$  actually measured  $.715"$  which is  $.011"$  out of tolerance. This deviation was approved for use on the non-flight (S/N 1007) wrench only. The deviations mentioned above were approved by the proper NASA authorities and are reflected in detail on the Deviation Approval Request sheet included in the data pack.



### 3.0 SUMMARY

In fulfillment of this contract, Essex has produced and delivered to JSC via MSFC:

Two flight qualified EVA ratchet wrenches (S/N's 1005 & 1006)

One flight-like prototype (S/N 1007)

Data pack including:

six sets of engineering drawings

material certifications

inspection reports

test reports

three blank test sheets (for JSC testing)

deviation approval request sheet.

Delivery of the contract end items listed above was made on June 25, 1982 rather than the June 15 delivery date called for in the contract. The 10 day overrun was acceptable to the COR and other NASA officials due to the unusually short contract time allotted and the extra time required for setup of the quality assurance system.



#### 4.0 CONCLUSIONS AND RECOMMENDATIONS

In the production of the flight hardware described in this report, which is Essex' first flight hardware contract, a few noteworthy observations were made as are described below. In the purchase of raw materials and manufactured parts which must be stored in a controlled area with inventory records and test reports, it was found that over-purchase was the best policy. In purchasing more materials than are needed for the job, it is possible to remake nonconforming parts or remake parts due to design changes without the extra paperwork involved with purchasing additional certified materials. Similarly, in fabricating more parts than are actually needed for a job, the chance of a bottleneck in assembly caused by nonconforming parts is reduced.

In the fulfillment of contract requirements, Essex has developed the capability for the production of flight hardware, particularly small equipment such as the EVA ratchet wrench. With knowledge gained from flight hardware production, an in-house quality assurance capability, and an on-hand inventory of certified materials and parts, Essex is now capable of producing EVA ratchet wrenches with streamlined efficiency.